Photo: Lake Ototoa, Auckland. (Source: ARC).

4.3

State of the environment and biodiversity – Freshwater

Contents 4.3

4.3

Freshwater

Introduction

The plentiful rainfall across the Auckland region sustains a wide variety of freshwater environments including all the rivers, lakes and wetlands on the surface as well as the hidden store of groundwater. These freshwater environments support numerous ecosystems, providing habitats for birds, plants, insects, invertebrates, fish and amphibians. The quality and quantity of freshwater required to support these ecosystems is of high importance.

Freshwater is a vital, but limited, resource that is essential to life. Without sufficient, clean freshwater, human health, cultural health, the economy and agricultural output would all decline. Freshwater features such as rivers and lakes also enhance the landscape, as well as providing an important resource for recreational activities such as swimming, freshwater fishing, and kayaking.

Water is a fundamental taonga (treasure) to Māori, who have cultural, historical and spiritual links with many of the rivers, lakes and wetlands in the Auckland region.

Under the provisions of the RMA, water is taken from surface waters (rivers and lakes), abstracted from groundwater through boreholes or collected from rainwater. However, as the population of the Auckland region continues to grow and land use practices intensify, managing the freshwater resources in order to ensure a reliable supply of freshwater while maintaining the health of the freshwater ecosystems, becomes even more critical. Therefore, the ARC needs to understand the quantity and quality of the freshwater resources and identify changes and long-term trends in order to manage it effectively and make informed decisions.

ARC's freshwater monitoring programmes help the ARC to characterise the environmental and ecological characteristics of the freshwater resource and to understand the effects of environmental stressers upon it. However, the ARC programme monitoring does have limitations. It is impossible to comprehensively monitor the entire region therefore, the ARC monitors a selection of sites using measures that are selected for their relevance to environmental pressures. The sites are selected to be representative of the whole freshwater resource in the Auckland region; this means that the ARC monitors all sizes and types of freshwater and cover the range of land cover types found in catchment across the Auckland region.

Note: The RMA defines a 'river' as a continually or intermittently flowing body of freshwater, including streams and modified watercourses. The term 'river' is used in this chapter consistent with this definition.

Rivers

Key findings

- The Auckland region has around 16,500km of permanent rivers and most are relatively small (less than a few metres wide). Most (63 per cent) flow through non-forested rural land and 21 per cent flow through native forest.
- River water quality is strongly related to the type of land cover in the surrounding catchment area. Native forest sites have the best water quality and urban sites have the worst. However, trends indicate that urban river water quality improved between 1995 and 2005.
- The ARC ecological monitoring programme showed a similar pattern in relation to the catchment land cover. Native forest rivers had healthy biological communities but urban streams had an impoverished fauna.

Introduction to rivers

The Auckland region has thousands of kilometres of rivers, ranging from tiny headwaters to the largest, the Hoteo River (Box 1). The water in any river comes from all the seeps, springs and surface runoff in its catchment area. As these flow downhill they merge, forming a permanent river that eventually flows to sea.

The Strahler order system allows the ARC to classify permanent rivers based on the size and number of their tributaries (Figure 1). A river with no tributaries is classified as first order. When two first order rivers merge, they form a second order river. When two second order rivers merge, they form a third order river. Rivers only increase in order when two tributaries of the same order merge, e.g. if a second order river merges with a third order river, the river remains as third order. Therefore, a third order river becomes a fourth order river only when it merges with another third order river.

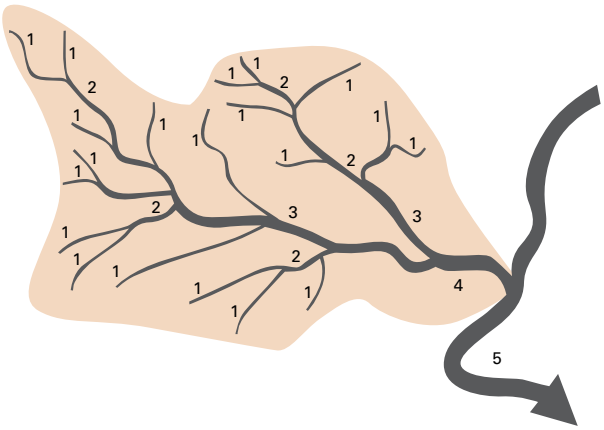


FIGURE 1 The Strahler order system. (Source: U.S Army Corps of Engineers).

Freshwater

As no mainland location in the Auckland region is more than 20km from the coast, the catchment areas of each river are relatively small. This means that most of the rivers reach the sea before they merge with others to form large rivers. Consequently, most rivers are first and second order (Table 1), meaning that they are relatively small and usually less than a few metres wide. These small catchments are characteristic of the Auckland region and mean that only 3 per cent of the rivers are fifth order and greater.

The relatively low elevation of the Auckland region and the underlying geology of the land also have a profound influence on the nature of the rivers, usually resulting in slow flowing, low gradient rivers with soft bottomed beds. Fast flowing, high gradient rivers with stony, hard bottoms are mostly restricted to catchments that drain the higher areas in the Waitakere Ranges and the Hunua Ranges.

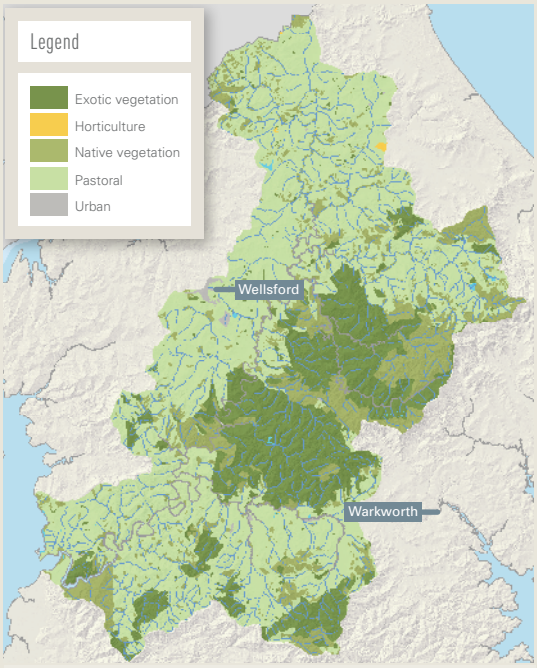
TABLE 1 Permanent rivers in the Auckland region classified by the Strahler order system. (Source: ARC).

Strahler order	Length (km)	% in order	Cumulative %
1	8753	52.7	52.7
2	4262	25.6	78.3
3	2121	12.7	91.0
4	1003	6.0	97.0
5	372	2.2	99.2
6	122	0.7	99.9
7	16	0.1	100
Total	**16,650**	**100**	

Box 1 The Hoteo River – the biggest in the Auckland region

The Hoteo River area drains nearly 8 per cent of the Auckland region. It is the biggest river in the Auckland region, by both flow and catchment area. Its headwaters are around Wellsford and it drains into the Kaipara Harbour near Mangakura. The Hoteo is seventh order at its mouth and has a catchment area of 405km^2. The catchment area is mainly rural (78 per cent) with areas of native forest (9 per cent) and exotic forest (13 per cent).

The Hoteo discharges 175 gigalitres every year on average (1 gigalitre is 1,000,000,000 litres). Although it is the biggest river in the Auckland region, it is relatively small on a national scale, e.g. the Waikato River discharges over 12,000 gigalitres each year.



Land cover by type in the Hoteo River catchment.

4.3

Freshwater

Box 2 Examples of permanent, intermittent and ephemeral rivers in the Auckland region

Permanent

The Wekatahi River in the Waitakere Ranges. This type of river flows all year round.

Intermittent

An unnamed tributary of the Okura River. This type of river flows for most of the year, but dries up in prolonged dry periods; it usually has a clear channel within defined banks.

Ephemeral

An unnamed tributary of the Mahurangi River. This type of river is dry most of the time and flows only after rainfall, it does not usually have a clear channel or defined banks.

It is difficult to determine the exact total length of rivers in the Auckland region for a variety of reasons. Our current best estimate, based on remote sensing and GIS analysis is 28,240km consisting of:

- 16,650km of permanent rivers
- 4480km of intermittent rivers
- 7110km of ephemeral rivers.

See Box 2 for descriptions and examples of these river types.

The River Environment Classification (REC) scheme has classified each river in New Zealand by the type of land cover in its surrounding catchment. Land cover affects the quality and quantity of water, the types of ecological habitats in the river and its flow patterns. The REC is based on the following types of land cover:

- native forest (including natural alpine environments)
- exotic forest
- rural (includes all non-forested rural land)
- urban.

The majority (63 per cent) of rivers within the Auckland region drain non-forested rural catchments (pastoral farming, horticulture and rural residential), followed by native forest catchments (21 per cent), with exotic forest and urban catchments accounting for 8 per cent each (Table 2). This shows that the proportions of catchment land cover types for rivers within the Auckland region are quite different from the rest of New Zealand.

These differences reflect the high population density in the Auckland region and the environmental pressures associated with this. For example, 8 per cent of rivers in the Auckland region have urban catchments compared with only 1 per cent nationwide. The Auckland region also has fewer rivers with native forest catchments (21 per cent) compared to the country as a whole (51 per cent).

In addition to the differences in catchment land cover types, all rivers show natural variation between their source and the sea as they increase in size, decline in gradient and accumulate increasing amounts of nutrients and sediment. This natural variation, together with the effects from different types of catchment land cover, produces a wide range of environmental conditions that, in turn, provide a wide range of ecological habitats.

TABLE 2 Proportions of catchment land cover types for rivers in the Auckland region compared to the whole of New Zealand (2005). (Source: ARC, MfE).

Type of land cover	Percentage of rivers	
	Auckland region	New Zealand
Rural	63	43
Native forest	21	51*
Exotic forest	8	5
Urban	8	1

*Includes Alpine environments which are not found in the Auckland region.

River monitoring programmes

The ARC operates three river monitoring programmes:

- **Water Quantity Programme.** This monitors river level and flow at 32 sites across the Auckland region. The hydrological data is collected automatically through a range of sensors and sent to the ARC by a telemetry network. The hydrological data is also complemented by a network of 37 rainfall stations. Collectively, the data enable the ARC to determine long-term trends in the hydrology, more accurately predict the extent of flooding and impacts of droughts, and support our water quality and ecological monitoring programmes (described below).
- **Water Quality Programme.** This monitors some of the physical, chemical and microbiological properties of rivers at 27 sites (Figure 4) around the Auckland region once each month. It provides information on the water temperature and amount of nutrients, oxygen, sediment and other pollutants in the rivers. The results enable the ARC to assess the life-supporting capacity of the river (how suitable it is for supporting plant and animal life) and the microbiological quality of the river (how suitable it is for recreational use and for stock to drink).
- **The Ecological Quality Programme.** This monitors the type and number of invertebrates (such as insects, crustaceans, worms and snails) found at up to 64 sites (Figure 6) around the Auckland region once a year. The type and number of invertebrates found at a site are used to indicate the ecological quality of the river.

The three monitoring programmes are regionally representative. This means that they monitor all sizes and types of rivers, and also cover the range of different catchment land cover types found across the Auckland region. The overall aim is to characterise the environmental and ecological characteristics of the rivers and to understand the effects of different land cover types upon them.

Surface water quantity programme

The rainfall, river levels and river flows in the Auckland region have been monitored continuously since 1975. This lengthy dataset is extremely useful as it enables the ARC to build up a picture of the hydrological systems in the Auckland region, including studies on climate and weather patterns, the probabilities of river flooding and the effects of the aftermath of droughts such as that in 1993/94.

Understanding and predicting effects of land use, development, urbanisation and other human activities on water resources is an important hydrological issue in Auckland.

Indicator 1: Regional rainfall

The Auckland region on average received 14 per cent more rainfall in 2008/09 than 2007/08, with increased rainfall recorded at all hydrological sites over this period (Figure 2).

During the latter half of 2008 the Auckland region experienced average rainfall, except for September which was exceptionally dry (up to 42 per cent below average). Although 2009 began with a drier than normal January, this was easily countered by a very wet February with double the amount of rainfall normally expected (Figure 3).

Indicator 2: Regional river flows

The Auckland region experienced one large flood event between June 2008 and May 2009 (see Floods in Chapter 5.1 page 262 for information on other flood events).

This event occurred on 30 July 2008 when flow at the Mangawheau River, Hunua was recorded at a 1 in 22 year annual return period (Table 3). (An annual return period is a statistical estimate of the likelihood of a given discharge occurring in any single year).

The higher than average rainfall across the Auckland region that was identified in Indicator 1 is reflected in higher than average discharges at all of the hydrology sites the ARC monitors (Table 3). For example, between June 2008 and May 2009 the Kaipara and North Shore rivers that the ARC monitors had discharges up to 34 per cent higher than the long-term annual average discharge.

4.3

Freshwater

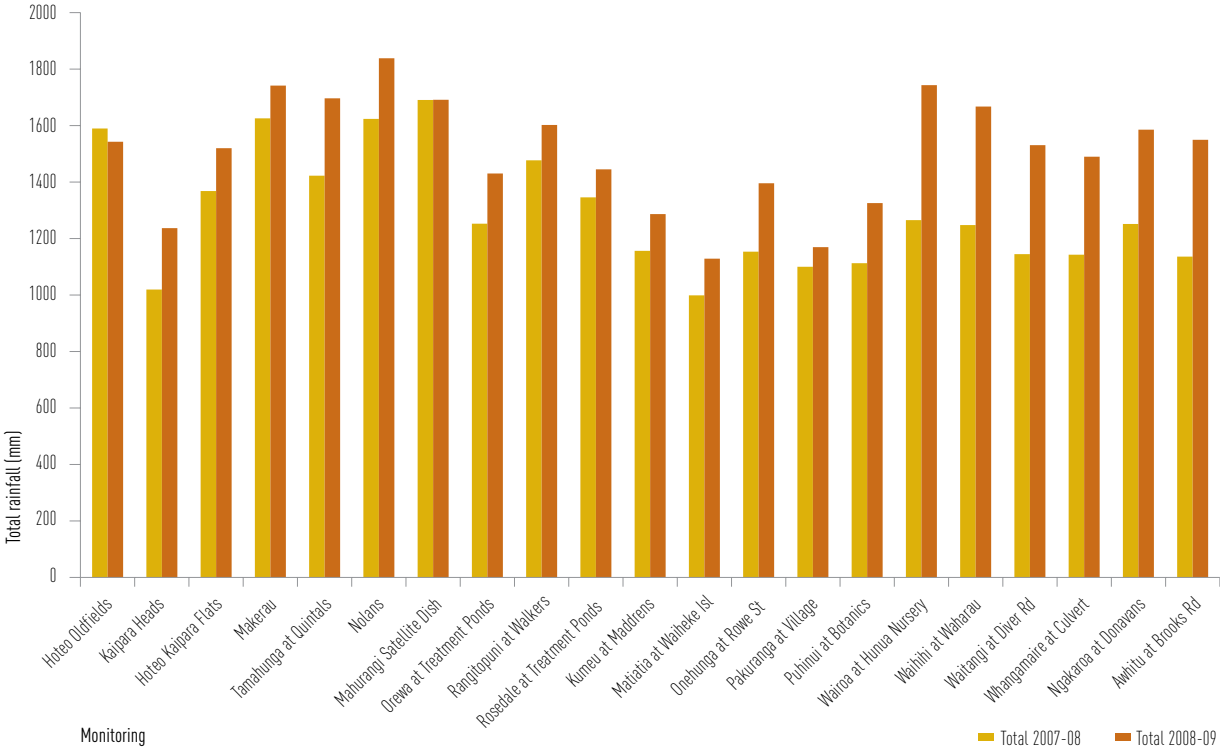


FIGURE 2 Comparison of 2007/08 and 2008/09 rainfall totals at selected monitoring sites across the Auckland region. (Source: ARC).

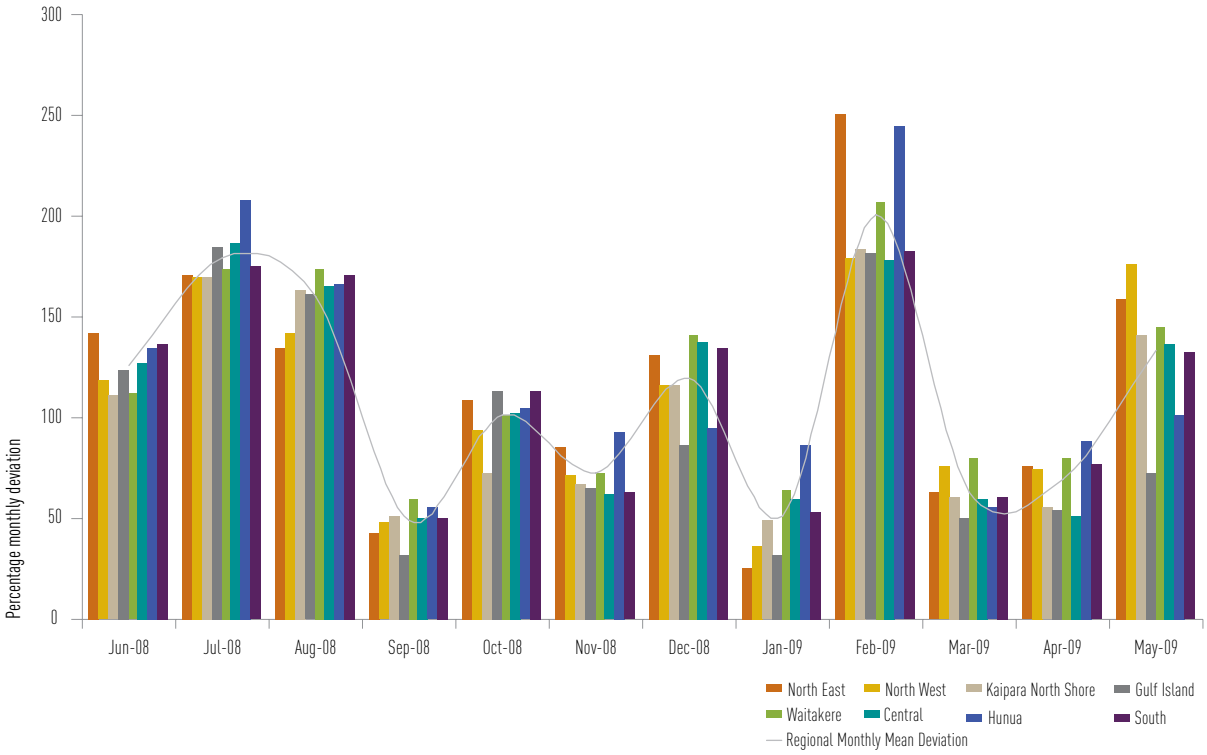


FIGURE 3 Percentage deviation of the 2008/09 regional monthly rainfall against the long-term monthly average at selected monitoring sites across the Auckland Region. (Source: ARC).

TABLE 3 Comparison of river flows (m^3/s) at ARC hydrological sites between June 2008 and May 2009, with the long-term data record. (Source: ARC).

Water resource region	River	Long-term annual average discharge	Annual average discharge (June 2008 to May 2009)	% difference annual average discharge	Largest recorded discharge (on 30 July 2008 unless shown otherwise)	Annual return period
Auckland Central	Mangemangeroa	0.048	0.053	10.9	6.43	1.9
	Meola	0.154	0.185	20.0	4.02	1.2
	Puhinui	0.194	0.235	21.0	12.0	1.6
	Papakura	0.847	1.011	19.4	48.2	5.9
	Otara	0.299	0.365	22.1	24.9	1.8
Hunua	Mangawheau	0.692	0.837	21.1	69.3	22.7
	Wairoa	2.714	3.191	17.6	171	9.2
Kaipara – North Shore	Oteha	0.211	0.267	26.6	17.5	1.4
	Kumeu	0.945	1.079	14.1	42.9 at 24 Aug 2008	4.7
	Rangitopuni	1.473	1.633	10.9	110	2.7
	Oratia	0.657	0.720	9.6	43.3 at 24 Aug 2008	1.2
	Swanson	0.529	0.595	12.6	63.4 at 24 Aug 2008	2.2
	Opanuku	0.655	0.756	15.4	58.4 at 24 Aug 2008	1.9
	Kaipara	2.944	3.948	34.1	96.9 at 24 Aug 2008	4.3
	Ararimu	1.116	1.459	30.7	44.5 at 24 Aug 2008	3.5
North East	Tamahunga	0.190	0.238	25.3	18.4	1.6
	Mahurangi	1.164	1.448	24.4	112	5.2
	Orewa	0.174	0.231	32.5	40.4	3.5
North West	Kaukapakapa	1.215	1.335	9.9	111	9.7
	Waiteitei	1.839	2.259	22.8	104	2.3
	Hoteo	5.892	7.317	24.2	162	3.5
South Auckland	Ngakaroa	0.092	0.112	22.4	4.39	5.4
	Whangamaire	0.138	0.149	7.5	1.19	4.9
	Waitangi	0.236	0.283	19.9	18.9	6.1
Waitakere	Robinsons	0.008	0.010	22.6	0.22 at 24 Aug 2008	N/A

4.3

Freshwater

Water quality monitoring programme

Seven water quality parameters were used to assess the life supporting capacity of river water at each of the 27 monitoring sites (Figure 4). These parameters are:

- dissolved oxygen
- pH
- turbidity
- ammonia
- temperature
- total phosphorus
- total nitrogen.

The levels of these parameters at each monitoring site were evaluated for compliance with the target levels (thresholds) for life supporting capacity that are derived from national guidelines (Box 3). Some of the national guidelines were refined to better reflect the natural range found at monitoring sites within the Auckland region. For example, the temperature of rivers in the region are naturally higher than that of rivers in the South Island so the target level has been adjusted to account for this.

Box 3 Calculation of Water Quality Index (WQI)

The results were used to produce four water quality indices that enables the ARC to assign a water quality class to each monitoring site. This methodology was developed and described by the Canadian Council of Ministers of the Environment (2001). The four indices that are used to assess the water quality – for both freshwater and marine water – are:

- **Scope**. This represents the percentage of parameters that failed to meet the compliance thresholds at least once (the lower this index, the better).
- **Frequency**. This represents the percentage of all individual tests that failed to meet the compliance thresholds (the lower this index, the better).
- **Magnitude**. This represents the amount by which failed tests exceeded the compliance thresholds (the lower this index, the better).
- **WQI**. This represents an overall Water Quality Index for ecological health based on a combination of the three indices described above (the higher this index, the better).

This Water Quality Index (WQI) enables the ARC to assign an overall water quality class using the following ranges:

- Greater than 90 = Excellent water quality
- Between 70 and 90 = Good water quality
- Between 50 and 70 = Fair water quality
- Lower than 50 = Poor water quality.

Indicator 3: Water quality

Site based

Monitoring data for the seven water quality parameters were used to produce the four water quality indices for each of the 27 sites (Table 4) and the overall WQI index was calculated to determine a water quality class for each site. The location and quality class of each site is shown in Figure 4).

Two native forest sites, Cascades and West Hoe, met all the target levels. The other site with Excellent water quality, Mahurangi Forest, drains a catchment that contains exotic forest. These three sites are the only ones in the monitoring programme that have catchments covered entirely or predominantly in forest, and clearly show the benefits of this type of land cover with regard to the water quality.

The value of forest land cover is also demonstrated by the four sites that have Good water quality; although the predominant land use in these four catchments is rural, all have more than 40 per cent of the catchment covered by either native or exotic forest.

All of the sites with Poor water quality were located in predominantly urban catchments and these sites typically exceeded the compliance thresholds for all variables (with the exception of pH) on multiple occasions during the year. All of these sites also failed more than 20 per cent of the individual tests and the magnitude of the exceedences was generally high.

TABLE 4 The river water quality monitoring network and water quality class. (Source: ARC).

Rank	Site name	Scope	Frequency	Magnitude	WQI	Water quality class
1	Cascades	0	0	0	100	Excellent
2	West Hoe	0	0	0	100	Excellent
3	Mahurangi Forest	14.3	1.3	0.8	91.7	Excellent
4	Mahurangi W.T.P.	42.9	8.3	2.4	74.8	Good
5	Mahurangi Town Centre	42.9	9.5	3.4	74.6	Good
6	Matakana	42.9	8.4	6.7	74.5	Good
7	Waiwera	42.9	10.8	2.9	74.4	Good
8	Opanuku	57.1	6.0	1.6	66.8	Fair
9	Hoteo	57.1	12.0	2.2	66.3	Fair
10	Kumeu	57.1	20.0	15.9	63.9	Fair
11	Vaughans	57.1	23.2	13.1	63.6	Fair
12	Rangitopuni	71.4	20.5	8.0	56.8	Fair
13	Wairoa	71.4	20.2	10.3	56.7	Fair
14	Oteha	71.4	19.5	13.3	56.6	Fair
15	Oakley	71.4	20.2	13.0	56.5	Fair
16	Lucas	71.4	22.9	18.4	55.4	Fair
17	Okura	71.4	28.4	8.6	55.3	Fair
18	Pakuranga @ Greenmount	71.4	29.8	12.6	54.7	Fair
19	Papakura	71.4	31.3	13.9	54.3	Fair
20	Ngakaroa	71.4	20.2	30.0	53.8	Fair
21	Otara @ East Tamaki	71.4	31.0	27.7	52.3	Fair
22	Otara @ Kennel Hill	85.7	23.8	9.3	48.4	Poor
23	Pakuranga @ Guys Road	85.7	22.6	20.2	47.5	Poor
24	Pakuranga @ Botany	85.7	31.0	9.1	47.1	Poor
25	Puhinui	85.7	33.3	12.8	46.4	Poor
26	Omaru	85.7	44.0	27.8	42.1	Poor
27	Otaki	85.7	46.4	61.4	33.5	Poor

4.3

Freshwater

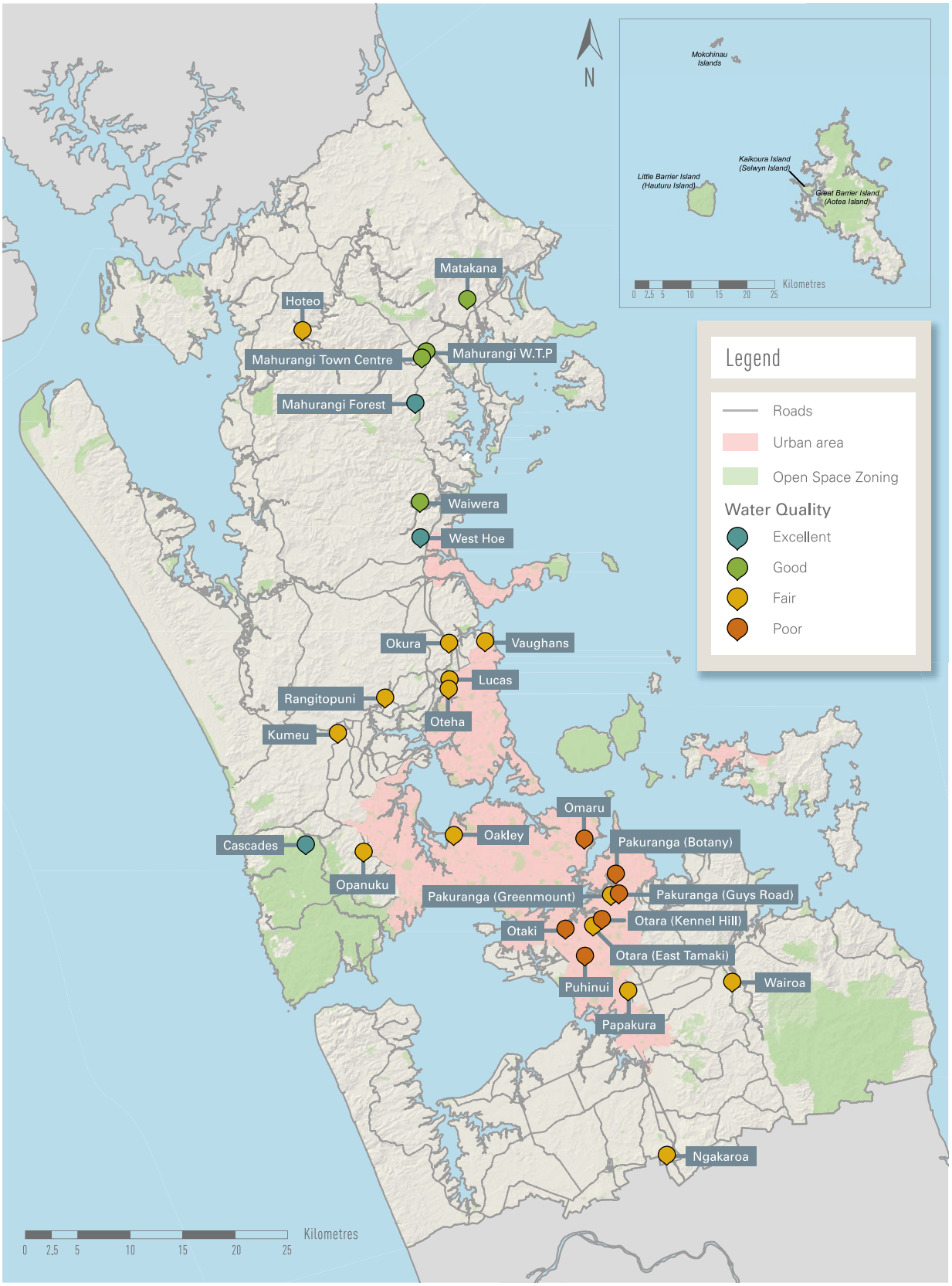


FIGURE 4 The river water quality monitoring network and water quality class. (Source: ARC).

Land cover based

To assess the effect of land cover on water quality for ecological health, the 27 sites in the monitoring programme were assigned to one of three land cover types (forested, rural or urban) on the basis of the predominant land cover in their catchments. (Native and exotic forest sites were combined into the same class because of the low number of sites).

The average values for each of the water quality indices shown on page 146 were then calculated for each land cover type.

Table 5 shows that forested sites, with an average WQI score of 97.2, clearly produce the best water quality scores. In contrast, urban sites clearly have the worst water quality with an average WQI score of 49.1. The rural sites, with a average WQI score of 64.3, were between the forested and urban land use types.

TABLE 5 Average WQI scores for all sites within a land use type. (Source: ARC).

Land use type	Scope	Frequency	Amplitude	Average WQI
Forested	4.8	0.4	0.3	97.2 (Excellent)
Rural	58.2	16.8	9.2	64.3 (Fair)
Urban	79.2	29.5	20.5	49.1 (Poor)

This result is reinforced when the percentage of sites in each water quality class are stratified by land cover within the catchment. Table 6 shows that all of the forested sites were classified as having Excellent water quality, rural sites had either Good (31 per cent) or Fair water quality (69 per cent), and urban sites had Fair (45 per cent) or Poor (55 per cent) water quality.

TABLE 6 Percentage of sites in each WQI class, by land use type. (Source: ARC).

Land use type	Excellent	Good	Fair	Poor
Forested	100	0	0	0
Rural	0	31	69	0
Urban	0	0	45	55

Trends by land cover type

The 2007 River Water Quality – State and Trends report analysed trends in water quality parameters between 1995 and 2005. This analysis was used to identify trends in the six water quality parameters that are used to assess the life supporting capacity of the water (pH was not included).

For both forested and rural sites, the majority of sites showed no change between 1995 and 2005. A small percentage of sites showed improvements; the most notable being decreasing nitrogen levels at several rural sites (Table 7).

The strongest trends were in urban rivers, where half of the trends indicated improvements in water quality. Improving trends were identified across all the urban sites and were particularly noticeable for:

- → ammoniacal nitrogen (declining levels at five sites)
- → nutrients (decreasing nitrogen at eight sites and decreasing phosphorus at eight sites)
- → turbidity (declining levels at seven sites).

There was little significant change in the level of dissolved oxygen or water temperature.

When the trend analysis was summed for all sites, most parameters at most sites showed either no change or an improvement in the water quality for ecological health. The small number of declining trends showed no consistent pattern but one site (Wairoa), showed declining trends in three parameters (dissolved oxygen, ammoniacal nitrogen and turbidity).

TABLE 7 Percentage of parameters at all sites that are improving, showing no change or declining, stratified by land cover. (Source: ARC).

Land use type	Percent improving	Percent not changing	Percent declining
Forested	16	83	0
Rural	15	76	8
Urban	50	47	3
All sites	31	63	5